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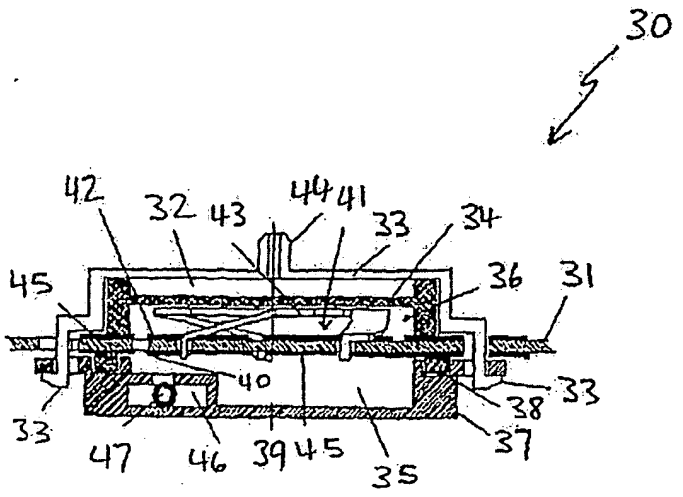
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SEALED CAPACITIVE PRESSURE SENSOR FOR NON-INVASIVE BLOOD PRESSURE MONITOR



(57) Abstract: A sealed capacitive pressure sensor (30) has a body with a first (32) chamber and a second chamber (35). The chambers are separated from each other y a printed circuit board (31). The first chamber (32) has an air inlet (44) and at least one opening (40) into the second chamber (35). A flexible membrane (34) is located in the first chamber (32) to form two sealed cavities (32, 36) in the body. A first cavity (32) is formed between the air inlet (44) and the flexible membrane (34) and a second cavity (35) is formed by space (36) in the first chamber on other side of the flexible membrane and the space (39) in the second chamber (35). A capacitor is located in the second cavity (35) within the first chamber portion (36) of the second cavity (35). The capacitor is formed by a pair of electrodes (42,43) adapted to have variable spacing between them according to the air pressure within the first cavity (32). One electrode (42) can be a copper layer on the printed circuit board (31), while the other (43) can be formed from a disc spring. The air pressure within the second cavity (35), which can change with temperature, equalises between the first chamber portion (36) and the second chamber portion (39) of the second cavity due to movement of air through the opening (40).

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SEALED CAPACITIVE PRESSURE SENSOR FOR NON-INVASIVE BLOOD PRESSURE MONITOR

FIELD OF THE INVENTION

The present invention relates to the field of blood pressure monitors and, in particular to, an oscillometric blood pressure monitor which measures air pressure using a capacitive pressure sensor.

BACKGROUND OF THE INVENTION

Oscillometric blood pressure monitors calculate blood pressure values using analysis of air pressure fluctuations transmitted from an arm cuff to a pressure sensor.

Low cost blood pressure monitors use capacitive pressure sensors composed of two parallel metal plates that form a capacitor. Distance between the capacitor plates and their area define capacitance of the capacitor. While the area of the plates remains constant, the distance between the plates is variable and proportional to external pressure applied to one of the plates of the capacitor. The capacitor defines frequency of the electronic oscillator. The frequency of the oscillator is inversely proportional to the pressure applied to the sensor pressure. An air gap separates the plates of the capacitor.

Properties of the capacitor dielectric or air gap in the capacitive pressure sensor affect its capacity. Changes in humidity and temperature change dielectric properties of the air and in turn, capacitance of the pressure sensor. Variations in humidity lead to a different rate of oxidation of the metal surface of the capacitor plates. These unwanted long term changes of the capacitance of the pressure sensor are very difficult to predict and compensate. This makes capacitive pressure transducers less reliable.

It will be an advantage to provide a sealed air gap in the capacitive pressure transducer in order to eliminate effects of the humidity variations in digital blood pressure monitors.

It is believed that improvements in accuracy of a capacitive pressure monitor can be achieved by providing a constant humidity air gap. It is also believed that it would be advantageous to provide a sensor whereby reliability is increased as well as lowering manufacturing costs.

OBJECT OF THE INVENTION

It is therefore an object of the present invention to provide a non-invasive oscillometric blood pressure monitor which substantially overcomes or ameliorates the above mentioned

disadvantages. At the very least, the invention provides an alternative to previously known monitors.

DISCLOSURE OF THE INVENTION

According to one aspect of the present invention, there is disclosed a a sealed capacitive pressure sensor having a body with a first chamber and a second chamber, said first chamber having an air inlet and at least one opening into said second chamber; a flexible membrane means located in said first chamber to form two sealed cavities in said body, a first said cavity being formed between said air inlet and said flexible membrane and a second said cavity being formed by space in said first chamber on other side of said flexible membrane and the space in said second chamber; a capacitor located in said second cavity within the first chamber portion of said second cavity, said capacitor being formed by a pair of electrodes adapted to have variable relative spacing between them according to the air pressure within said first cavity, wherein the air pressure within the second cavity equalises between the first chamber portion and the second chamber portion of the second cavity due to movement of air through said at least one opening.

Preferably, the capacitor is formed from a stationary disc electrode fixed to a wall of the first chamber and a disc spring electrode in a plane spaced apart from the stationery disc electrode , and with the disc of the spring being adapted move relative to the position of the stationery disc electrode.

Preferably, the flexible membrane is adapted to abut against the disc of the spring.

Preferably, the wall between the two chambers is formed by a printed circuit board, the stationery disc electrode being attached to or being part of the printed circuit board with the spring electrode being connected directed to the printed circuit board and therefore having direct contact.

Preferably, shielding means is provided to prevent electromagnetic interference.

BRIEF DESCRIPTION OF THE DRAWINGS

One embodiment of the invention will now be described with reference to the accompanying drawings in which:

Fig. 1 is a partial transverse cross section view of a typical capacitive pressure transducer of the prior art;

Fig. 2 is a partial transverse cross sectional view of a capacitive pressure transducer according to one embodiment of the present invention;

Fig. 3 is a plan view of a spring used in the transducer of Fig. 2; and

Fig. 4 is a transverse cross sectional view of the spring of Fig. 3.

BEST MODE OF CARRYING OUT THE INVENTION

Referring to Fig.1, a typical capacitive pressure transducer 10 is shown. The pressure transducer 10 is mounted on a printed circuit board 11. A top plate 12 of a capacitor 13 is located by spacers 14, screws 15 and nuts 16 parallel to the printed circuit board 11. A second plate 17 of the capacitor 13 is attached to a flexible membrane 18 of a sealed chamber 19. The sealed chamber 19 is attached to the printed circuit board by the aid of the screws (not shown). An air inlet 20 is connected to the pneumatic circuit of the blood pressure monitor. When air pressure is applied to the chamber 19 via the air inlet 20, the flexible membrane 18 expands and moves plate 17 towards the top plate 12. When the air pressure is removed, the plate 17 returns to its original position. The capacitor plates 12 and 17 are connected to an electronic oscillator 21 via wires 22 and 23, respectively. A shield 24 which is in the shape or form of a metal can over the transducer 10 shields the transducer from external electromagnetic interference. The shield is mechanically and electrically connected to a ground plane 25 of the printed circuit board 11. Several soldered joints 26 are used to connect the shield 24 to the circuit board 11.

As it can be seen, this type of construction presents significant problems to seal the air gap of the capacitor in order to control humidity between plates 12 and 17.

Manufacturing of the described above pressure transducer 10 requires precision stamping of the membrane 18, welding joints 27 of the sealed chamber 19, and precision soldering of the bottom plate 17. Assembly of this transducer 10 also requires extensive expert labour.

Referring to Fig. 2, a pressure transducer 30 of the preferred embodiment of the present invention is shown. The pressure transducer 30 is mounted on a printed circuit board 31 and has two sealed cavities, namely, a top cavity 32 being formed by a top cap 33 and the top section of a H-shaped flexible rubber like membrane 34, and a second sealed cavity 35 being formed by the bottom section of the H-shaped rubber membrane 34 and the printed circuit board 31 forming a first portion 36 of the cavity 35, a bottom cap 37 and a flexible rubber-like sealing ring 38 forming a second portion 39 of the cavity 35. When the transducer 30 is assembled, the H-shaped membrane 34 and sealing ring 37 are compressed, providing reliable sealing. The two portions 36 and 39 of the cavity 37 are joined by a hole 40 in the PCB 31.

A capacitor 41 is formed by a first plate 42 formed by a round copper layer of the PCB 31 and a second plate 43 formed by a spring which is soldered to the PCB 31. The transducer 30 has an air inlet 44 into the top cavity 32.

A bottom copper layer 45 of the printed circuit board 31 is electrically connected to the capacitor second plate 43 shielding the first plate 42 from external electromagnetic interference.

The transducer 30 operates such that when air pressure from a pneumatic circuit of the blood pressure monitor (not illustrated) is applied to the pressure transducer 30 via the inlet 44, the air pressure pushes the spring 43 via the flexible membrane 34. The flat surface of the spring 43 will move towards the bottom plate 42 of the capacitor 41 changing its capacitance. While the membrane 34 is pushed down by the external pressure and the spring 43 is compressed, the volume of the bottom cavity 35 is decreasing, creating an internal pressure. This internal pressure is in linear proportion with the displacement of the membrane 34, therefore it does not affect the overall linearity of the pressure transducer 30. However, in order to achieve high sensitivity of the pressure transducer 30, internal pressure resistance is minimized by the use of the large portion 39 of the bottom cavity 35 located below the PCB 31. Further extension of the bottom cavity 35 would make influence of the internal pressure negligible.

Furthermore, the transducer 30 further includes a small compartment 46 which contains an agent 47 that absorbs the moisture inside the bottom cavity 36.

Electrical connection of the capacitor plates does not require connecting wires because both plates have direct contact with the PCB copper deposit and

The transducer is preferably assembled using snap-feet latches.

Referring to the Figs. 3 and 4, the spring construction is shown. The springs 43 are punched from bronze-beryllium or bronze-manganese sheets.

The construction includes massive disk 48 that serves as a top plate 42 of the capacitor 41. Three legs 49 are formed as flexible springs as shown on Fig. 4. Solder terminals 50 are folded as shown in Fig. 4 and protrude through the printed circuit board 31 and are soldered to the bottom copper layer 45 of the printed circuit board 31. On the top layer of the printed circuit board 31 is the circular cooper deposit which forms the bottom layer 42 of the capacitor 41. The bottom copper layer 45 is the common ground node of the electrical circuit and the springs 43 are electrically connected to the bottom layer 45 of the

printed circuit board 31 which is the common ground node layer. The spring 43 and bottom layer 50 form a shield against external electromagnet interference.

As it can be seen, construction of the pressure transducer 30 uses low cost components and does not require precision assembly or adjustments.

Throughout the specification, the word "comprise" and its derivatives are intended to have an inclusive rather than an exclusive meaning unless the context requires otherwise.

The foregoing describes only some embodiments of the present invention, and modifications obvious to those skilled in the art can be made thereto without departing from the scope of the present invention.

CLAIMS

1. A sealed capacitive pressure sensor having a body with a first chamber and a second chamber, said first chamber having an air inlet and at least one opening into said second chamber; a flexible membrane means located in said first chamber to form two sealed cavities in said body, a first said cavity being formed between said air inlet and said flexible membrane and a second said cavity being formed by space in said first chamber on other side of said flexible membrane and the space in said second chamber; a capacitor located in said second cavity within the first chamber portion of said second cavity, said capacitor being formed by a pair of electrodes adapted to have variable relative spacing between them according to the air pressure within said first cavity, wherein the air pressure within the second cavity equalises between the first chamber portion and the second chamber portion of said second cavity due to movement of air through said at least one opening.

2. The sealed capacitive pressure sensor according to claim 1, wherein the capacitor is formed from a stationary disc electrode fixed to a wall of the first chamber and a disc spring electrode in a plane spaced apart from the stationery disc electrode, and with the disc of the spring being adapted move relative to the position of the stationery disc electrode.

3. The sealed capacitive pressure sensor according to claim 2, wherein the flexible membrane is adapted to abut against the disc of the spring.

4. The sealed capacitive pressure sensor according to claim 3, wherein the wall between the two chambers is formed by a printed circuit board, the stationery disc electrode being attached to or being part of the printed circuit board with the spring electrode being connected directed to the printed circuit board and therefore having direct contact.

5. The sealed capacitive pressure sensor according to claim 1, wherein shielding means is provided to prevent electromagnetic interference.

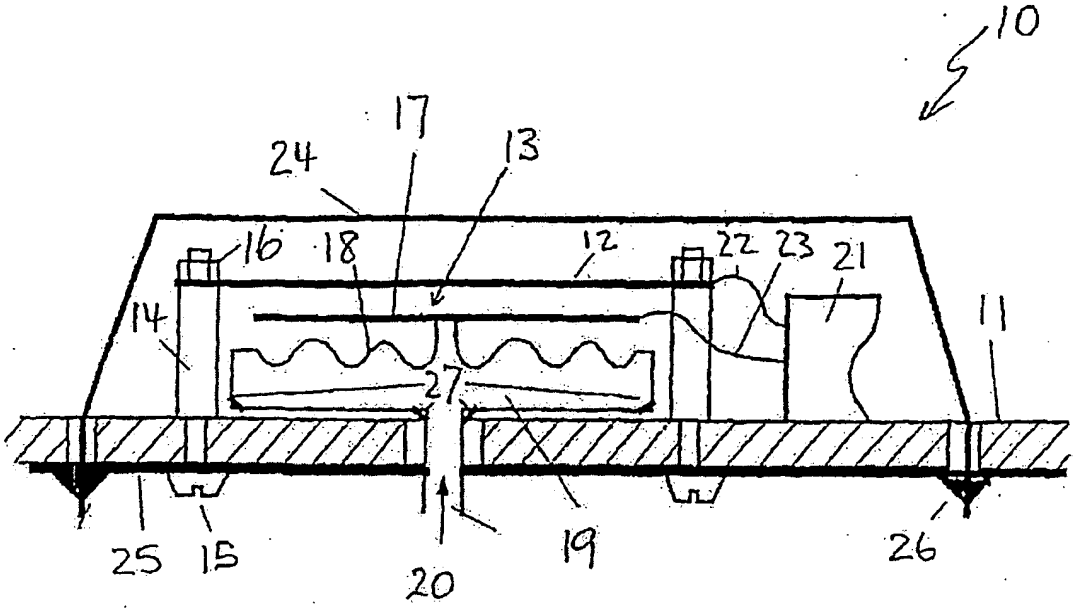
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Fig. 1

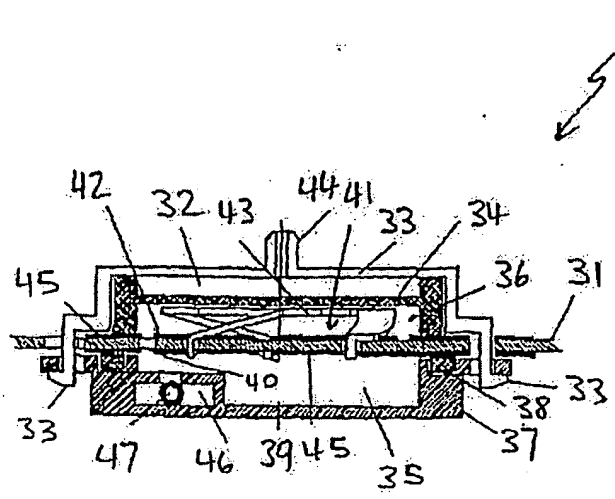
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Fig. 2

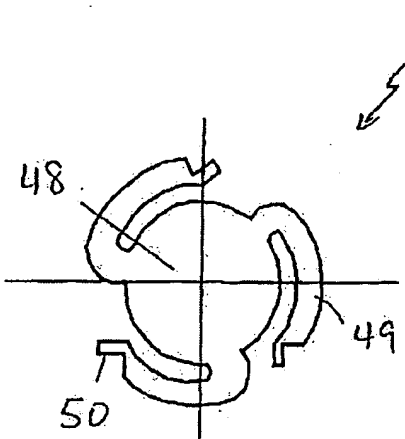

Fig. 4

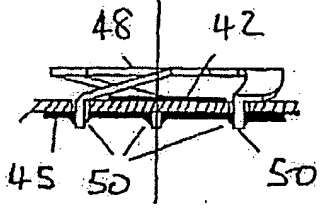

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2003/001567

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: G01L 9/12, 19/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI, JAPIO: pressure, capacitor, equalise, membrane, chamber and similar terms
USPTO: US Cl 73/708 and (73/718 or 73/724)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 7-306107 A (YAZAKI CORP) 21 November 1995 See machine translation from the Internet [2004-02-25] from URL: www4.ipdl.jpo.go.jp/cgi-bin/tran_web_cgi_ejje, see paragraphs 24, 28, 51-58, figure 1	1-5
X	US 4507972 A (MORITA) 2 April 1985 Column 4, lines 36-53, figures 1-9	1, 2, 5
X	US 4357834 A (KIMURA) 9 November 1982 Column2 lines 23-58, figure 1	1, 2, 5

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 February 2004	- 3 MAR 2004
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer GREG POWELL Telephone No : (02) 6283 2308

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2003/001567

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2156998 A (HEWLETT-PACKARD COMPANY) 16 October 1985 Abstract, figures	
A	US 6578427 A (HEGNER) 17 June 2003 Abstract, figures (& EP 1061351 A)	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2003/001567

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
JP	7-306107	NONE					
US	4507972	JP	57-033334				
US	4357834	NONE					
GB	2156998	DE	3510042	FR	2561514	JP	60-203234
		US	4572204				
US	6578427	CA	2311569	EP	1061351	JP	2001-021430

END OF ANNEX